# MORNING EXERCISES ON SCIENCE TOPICS

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The giving of morning exercises on science subjects offers great possibilities both to grade and high-school classes. So much material in the field of science is of general interest that a great variety of topics suitable for presentation can easily be found. The subjects chosen by high-school classes are frequently those which have already been studied in the elementary school. Often there is a conscious attempt to link up the experience of the younger children with the more advanced information that has been gained in high school. One of the main functions of high-school science should be to supply the pupil with the controlling principles which underlie many of the experiences and topics he has previously studied in more isolated fashion in earlier years. Once a pupil has grasped such a controlling principle and has learned to apply it to phenomena and experience familiar to him, he acquires a point of view which usually results in a real and lasting interest in science as well as in rapid and satisfactory progress as a student. Participation in preparing and giving morning exercises has directly helped many pupils to a more thorough grasp of such unifying ideas. In their effort to present their ideas simply and clearly to others, they have greatly clarified their own understanding.

Science exercises are almost always experimental. Besides the experiments, charts, diagrams, and models are frequently used to aid the explanations. Pupils realize that they must express their ideas in simple, non-technical language, and that the interest of the audience needs to be gained and held. The selection of experiments, and their adaptation for presentation to a large audience, requires real thought and careful planning.

Motion pictures[1] dealing with animal and bird life, with industries, and with life in foreign countries, have been found interesting to the entire school. To some extent such films can properly replace excursions to remote areas and to industries which hesitate to admit children of school age. On the other hand, morning exercises frequently grow out of the information and knowledge gained on such excursions.

As illustrations of the kinds of morning exercises given by high school classes, two given by the chemistry class have been selected, one being described in some detail and the other reported verbatim.

## I. CHEMISTRY OF WATER

Water, as a subject of science work, is studied from some point of view in each of the eight grades of the elementary school. Simple facts concerning the uses and properties of water are gained in the first and

[1] See list of sources for films of educational value, p. 191.

second grades through simple experiments and the work in cooking. The subject is more fully taken up in the third grade, in connection with the study of the city's history. The problem of Chicago's water supply leads to a simple study of the physics of water levels and pressures. The purification of water by processes of settling, filtration, and distillation, is worked out, using muddy and salty water. Several grades are concerned with water as a medium for the preparation of crystals of various kinds. The sixth grade makes an extensive study of atmospheric moisture, rain, dew, clouds, and related topics. The eighth grade, in the study of minerals, is interested in water as an agent for forming veins by methods of crystallization and precipitation. Also water is studied as a standard and means for the determination of the density of minerals using the principle of Archimedes. Many other points of contact might easily be enumerated. The group from the chemistry class, working on the preparation of this exercise, made a list of the points in which various grades might be interested. It was obvious that only a few of these could be utilized. After discussion, it was decided to make, as the main point of the exercise, the solvent power of water—that water as it comes from the ground contains dissolved materials and is "hard."

With this idea in view a week previous to the giving of the exercise its title was announced, and all members of the school were invited to bring in specimens of water from springs or wells, from as many different localities as possible. They were told that the chemistry class would test them and make a report on the interesting samples at the coming exercise. The response to this invitation was immediate, and a large number of samples were brought in from as many different sources. A report of the simple analysis, such as the class could make after eight weeks' study of chemistry, was given individually to each person bringing in a sample, and furnished much interesting work for the entire class.

### Outline of Exercise

The following outline will make clear the content of the exercise as presented.

1. *Composition.*—Water was decomposed by electrolysis into hydrogen and oxygen, using the familiar Hoffman apparatus. The acidulated water was colored bright red and placed in front of a white background to show the levels, and the two gases were separately identified. Water was also produced by direct combination of the two gases by applying a flame to a flask containing hydrogen and oxygen in approximately correct proportions, producing a sharp but not violent explosion, moisture being deposited upon the walls of the flask. The quantitative relations of the two gases combined in water was mentioned but not stressed.

2. *Water as a Basis for Measurement.*—Water is used for meas-

urement in several important ways. The boiling point and freezing points of water are used to graduate thermometers, both Fahrenheit and Centigrade. Water is used as a standard of density. To bring out this point equal volumes of mercury and water were quickly weighed and the resultant weights compared. Water is used to measure the power of other substances to hold heat. Equal weights of water and sand at the boiling temperature were removed from a steam bath and poured into equal amounts of cold water. After stirring, the resulting temperatures were read. Application of this principle was then made to the climatic effect of large bodies of water, especially Lake Michigan as a factor in controlling the climate of the Chicago area.

3. *Water as a Common Solvent.*—Experiments were performed to show the solubility of water for solids, liquids, gases, and the general effect of increased temperature on solubility. These experiments were carried on in large sized test tubes and with white and black backgrounds to make the results more easily visible.

4. *Water from Springs and Wells.*—Water coming from springs and wells is usually hard. The tests made at this point were confined to chlorides and sulphates. The tests themselves were explained and illustrated and then applied to several samples of water from the different sources, brought in by pupils.

Hard water is bad for washing and for use in boilers. Experiments were made to show how suds form readily in distilled water, whereas hard water makes a sticky precipitate. A section of a boiler tube was exhibited showing scale and the resulting inefficiency and loss of heat explained.

At the conclusion of the presentation there was opportunity for the audience to ask questions. These questions showed that the idea of density was fairly well understood, while the experiment with sand and water was not so clear. The pupil who presented this part of the exercise attempted to clear up the misunderstanding, with fair success. Another pupil asked if hard water was dangerous to the health of those drinking it. This question also was answered by a member of the class.

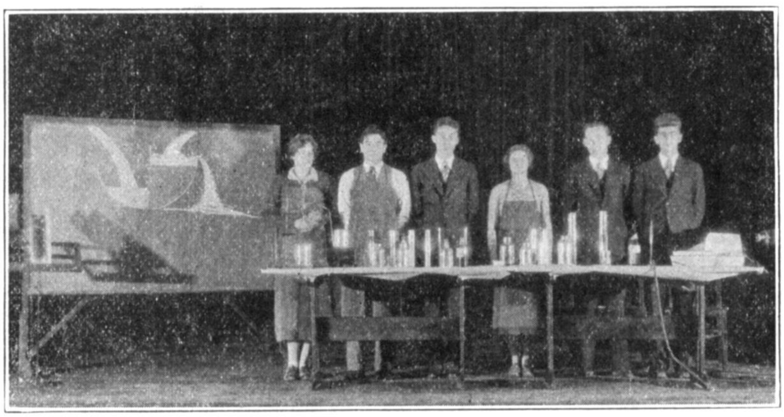
## II. TWO COMMON GASES—A CHEMICAL CONTRAST

*Lou.* This morning we are going to tell you about two common gases, and will show you some of their properties and uses. These two gases are called carbon dioxide and carbon monoxide. As their names indicate, they are made up of the same elements, carbon and oxygen, but their characteristics are very different.

First we shall take up carbon dioxide. This is a common gas, present in the air that we breathe at all times. Right now, every wood fire, every furnace burning coal, every chimney is sending out quantities of it into the air. It is formed whenever carbon or its compounds are burned, for that is what burning usually is, carbon uniting with oxygen, and giving off heat and light at the same time. Each one of us is a generator of carbon dioxide, for burning of a very slow sort goes on inside our bodies. We breathe in

the air with its oxygen, and we breathe out small quantities of carbon dioxide. Sometimes the other gas, carbon monoxide, is formed in burning, but this happens only when there is not enough oxygen to make carbon dioxide.

First of all I am going to make some carbon dioxide here on the stage. In this flask I have some broken pieces of marble (*flask is set up with thistle and delivery tube containing marble chips covered with distilled water*). Broken pieces of limestone would do just as well. If I add almost any kind of acid a chemical action will result, liberating carbon dioxide gas. I will pour in some hydrochloric acid (*does so*). The apparatus is so arranged that



*Ready for the Exercise on the Oxides of Carbon*

the gas passes through this tube and bubbles up into this large bottle which is filled with water. You can see the bubbles coming up into the bottle and pushing out the water. When the water is all gone the bottle will be full of pure carbon dioxide. (*Pours in more acid to speed up action.*) A good many of you have done this same thing when you have tested stones for limestone. You poured on a little hydrochloric acid and saw the bubbling effect, which told you that the rock was limestone. Now the bottle is full of carbon dioxide (*covers the mouth of the bottle with a glass plate and removes it from the pneumatic trough*). I light this splint of wood, and you look and see what happens when I lower it into the bottle of carbon dioxide (*the flame is extinguished*). You see, it goes out. This shows two things about carbon dioxide: it puts out fire, and it does not burn itself.

Now I am going to do an experiment for you which will show that carbon dioxide is a gas much heavier than air. Perhaps you think that gases are lighter than air, but this is not always true, as you will see. I light the candles in this trough (*lights four candles placed at intervals in the bottom of a three-foot trough inclined at an angle of about 45°, the lower end facing toward the audience*). This large jar is filled with carbon dioxide. (I filled it before the exercise to save time.) I am going to pour the carbon dioxide out of the jar. If the carbon dioxide is heavier than air, it ought to run down the trough and put out the candles one by one (*tilts the jar at the top of the trough and the candles are extinguished in order*). You see that is

just what has happened, and the experiment proves that carbon dioxide is heavier than air.

Now I shall show you something else about this gas. I have some lime water in this graduate. You see that it is perfectly clear, like water (*holds graduate in front of black cardboard*). Now watch what happens when I pass carbon dioxide through the lime water. (*Disconnects delivery tube from carbon dioxide generator and substitutes L-shaped tube, and lowers into the lime water. Very soon the lime water becomes milky in color.*) You see, the lime water turns a milky color. This is the way we know a gas to be carbon dioxide. If a gas passing through lime water produces this milky color, then that gas must be carbon dioxide. I said before that our breath contains small quantities of carbon dioxide. I will apply the lime-water test to prove that this is true. Here is another graduate with clear lime water. I will blow my breath through it. (*Blows through a glass tube into the lime water, which presently becomes cloudy.*) You see it turns a milky color, which proves that I am giving off carbon dioxide with my breath.

I have some litmus solution in these graduates. You see the litmus solution is a blue color. Litmus, as a good many of you know, is used to test for acids. It is really a blue dye, which is turned to a red color by any acid. Let us see whether carbon dioxide has any effect on litmus solution. You see, both tubes are now bright blue. (*Holds both graduates against the white background; thrusts the delivery tube of the generator into the solution in one of the graduates, which almost at once turns red. After a moment or two again holds both of the graduates against the white background.*) You see the one into which the carbon dioxide passed is turned red, while the other is still blue. This proves that carbon dioxide is an acid, or rather makes an acid with water.

*John.* The most common use of carbon dioxide gas is to manufacture carbonated beverages. Under pressure carbon dioxide is very soluble in water. That is, large quantities of it will dissolve in root beer or ginger ale when the bottles are filled under pressure. When you take off the stopper, the pressure is released and the gas escapes. (*Removes stopper from bottle of ginger ale and pours out into a graduate.*) The bubbles which you see forming and escaping are the carbon dioxide coming out of solution.

Baking powder, too, contains carbon dioxide. When you wet baking powder, the chemical action liberates carbon dioxide, just as the hydrochloric acid did on the marble chips in the generator. In the process of baking, the holes in the bread or cake are caused by the carbon dioxide bubbles liberated by the baking powder.

Carbon dioxide is also used to put out a fire. It is especially useful in putting out oil fires. For this purpose a substance called "Fire-foam" is used. Fire-foam is a mass of little soap bubbles filled with carbon dioxide. The fine soap bubbles are lighter than oil, so they stay on top and the carbon dioxide smothers the fire. If you try to use water to put out an oil fire, the water sinks to the bottom, and, in the case of an oil tank on fire, would cause the burning oil to overflow and thus spread the fire instead of putting it out. This experiment will show this use of fire-foam. The graduate is filled with soap solution. The tank is full of carbon dioxide. By turning the valve the gas will issue from the tank and bubble through the soap

solution. The soap bubbles which form will of course be full of carbon dioxide. In this pan there is some kerosene oil, with some cloth to act like a wick. I will set the oil on fire and then put it out with fire-foam. (*Lights the oil and after it is well started turns on the carbon dioxide gas from the tank. The stream of soap bubbles from the graduate falls into the pan and quickly puts out the fire.*)

Another form of carbon dioxide, which is quite new, is called "dry ice." Like every gas, carbon dioxide can be turned into a liquid by applying pressure and at the same time cooling. If we allow the liquid carbon dioxide to evaporate rapidly, it will produce a tremendous cooling effect, so great that the remaining liquid is frozen. I will use some of the liquid carbon dioxide in this tank to make some dry ice. First I will tie this bag over the valve of the tank and raise the other end so that the whole tank slants down. Now when I turn on the valve, the liquid carbon dioxide will rush into the bag and some of the liquid will be frozen into a white solid which looks a good deal like snow. (*Turns on the valve wide for a moment and then closes it. Removes the bag and carefully turns it inside out.*) You see this white material which looks like snow. It is solid carbon dioxide and very, very cold.

This is a block of dry ice that I got from the Liquid Carbonic Company this morning. (*Places package containing dry ice on the table and tears off the paper wrapping.*) It is used in place of ice for keeping things cold and for packing in refrigerator cars. Perhaps some of you have bought ice cream down town which has been packed in this kind of dry ice to keep it cold while you were taking it home. The dry ice will be out in the hall after the exercise. See how long it will last, but don't hold your hands on it. If you touch it quickly it will not hurt you, but if you press your hand against it, you are likely to get a frost bite that will feel just like a burn. It is called "dry ice" because it evaporates into carbon dioxide gas, which passes off into the air and thus leaves no liquid as would ordinary ice melting to water.

*Katherine.* The other gas which we are going to tell you about this morning is carbon monoxide. I have already made the gas, and have it here in these bottles in front of me. I made it by dropping formic acid into warm sulphuric acid. I will remove the glass cover from this bottle of carbon monoxide and will lower a blazing splinter into the glass (*gas burns with blue flame*). You see that carbon monoxide burns, and that the flame has a distinct blue color. You see this is exactly opposite to the way carbon dioxide behaved, because it did not burn, but rather put out the fire.

To another bottle of carbon monoxide I am going to add a little blue litmus solution to find out whether this gas has an acid effect or not. If the litmus solution turns red, I shall know that carbon monoxide is acidic, like carbon dioxide. (*Slips off the gas cover, pours some blue litmus solution, replaces the cover and shakes vigorously.*) You see there is no effect on the litmus; its color is still blue. Carbon monoxide is not acidic.

Now, I am going to burn this other bottle of carbon dioxide and then add litmus solution and shake well. (*Burns the bottle of gas and repeats the test with litmus solution.*) You see the litmus solution now turns red. This indicates that the gas which has been formed by burning carbon monoxide has an acid effect. Probably the gas now present is carbon dioxide. I will prove that this is true. Here is another bottle of carbon monoxide.

I am going to add some lime water, which Lou told us is a test for carbon dioxide. (*Adds lime water and shakes.*) You see the lime water does not turn milky, for the gas is still carbon monoxide. Now I am going to burn the gas. (*Lights it and again shakes it up with the lime water. After the flame dies down, replaces glass cover and shakes.*) You see the lime water turns quite cloudy, which is a test for carbon dioxide. This proves that when carbon monoxide burns carbon dioxide is produced. During the burning another part of oxygen is taken up. In carbon monoxide there is one part of carbon to one of oxygen, while in carbon dioxide there is one of carbon to two of oxygen. The names, monoxide and dioxide indicate these facts.

*Billy.* I am going to tell you about the poisonous qualities of these two gases. Carbon dioxide is not really poisonous, but you could not live long if you were surrounded by carbon dioxide. Oxygen is necessary to maintain life. You have seen how carbon dioxide smothers fire, that is, it shuts off the oxygen which is necessary to keep the fire going. In the same way carbon dioxide will shut off oxygen which is necessary to life, and thus cause death. On the other hand carbon monoxide is very poisonous and very dangerous, because it has no odor to warn you of its presence. If you breathe air for any length of time which contains relatively small amounts of carbon monoxide, you are likely to die. When carbon monoxide is breathed into the lungs it combines readily with the red blood corpuscles, thus preventing them from taking up the oxygen which they normally take up and carry to all parts of the body. When enough of the red blood corpuscles are thus affected, the victim will die by a kind of internal suffocation. Carbon monoxide is formed most commonly in the exhaust fumes of automobiles and in the gases given off by burning coal when the furnace or stove has been banked for the night. Many people die from carbon monoxide poison every year. Most commonly a man goes into his garage to work on his automobile and fails or forgets to open the doors or windows. He starts his engine and soon the garage contains a dangerous amount of poisonous carbon monoxide. Even small amounts of carbon monoxide will produce dizziness or headache.

Carbon monoxide is formed when coal is consumed, without an adequate supply of oxygen. It is quite commonly called coal gas, but its poisonous quality is due to the carbon monoxide which it contains. If the drafts up the chimney are too tightly closed, or if there are leaks or cracks about the furnace, the deadly gas may seep back up into the house, into the sleeping rooms and cause death to the sleeping occupants.

*Bernard.* (*In preparation for this part of the exercise, Bernard had prepared a large diagram on the blackboard of the carbon dioxide cycle, using colored crayons. He referred rather constantly to this diagram in his talk.*)

You have already been told that carbon dioxide is present in small amounts in the atmosphere at all times, and that burning coal, wood, etc., discharge large quantities of carbon dioxide into the air. All forms of animal life also are breathing it out. Decaying vegetation, rotting wood and leaves, too, liberate large quantities of carbon dioxide into the air. Scientists estimate that there is in the atmosphere 2,500,000 billion kilograms of carbon dioxide, and that each year 729 billion kilograms are produced from burning coal alone, while man alone produces an additional 439 billion kilograms of this gas. You would naturally think from these figures that

the amount of carbon dioxide in the air would steadily increase. However, this is not true. The constant production of carbon dioxide is exactly counterbalanced by the action of plant life. Plants just like animals breathe, but instead of breathing in oxygen and exhaling carbon dioxide, they do just the opposite, taking in the carbon dioxide out of the air and liberating oxygen, which goes back into the air. This whole matter is called the carbon dioxide cycle, which can perhaps be better understood from this diagram. The three circles represent the air, plant life and animal life. Animals breathe in oxygen and liberate carbon dioxide, which goes back into the air. Plants, on the other hand, take up carbon dioxide and give back into the air the oxygen which the animal life, including man, needs. Only when plants decay or are burned do they liberate carbon dioxide back into the air. Plants, of course, in their turn, are the food for animals. Plant and animal life thus balance one another and are mutually dependent, one upon the other.

When the plant takes in carbon dioxide out of the air into its leaves, and draws up water from the soil through its roots, under the influence of sunlight, the green leaves of the plant convert the carbon dioxide in the water into cellulose or starch or sugar, or into other plant foods. Since sunlight is necessary for this action, this process is called photosynthesis. So far modern chemists have not been able to duplicate photosynthesis in their laboratories except with great difficulty and high expense. Every green leaf is a chemical laboratory for converting carbon dioxide and water into plant food useful for animals and liberating oxygen, also necessary for the support of animal life.

*Joseph.* (*Joseph's part was to briefly summarize the exercise.*) Carbon monoxide, though poisonous, nevertheless has important uses in our daily lives. About half the gas which is used in our homes for cooking is carbon monoxide. Great quantities of carbon monoxide are used in smelting ores, especially iron and copper. When used for these purposes it is commonly called "producer gas." It is easily made by burning coal in great deep furnaces, admitting only enough air to form carbon monoxide.

The two gases, carbon monoxide and carbon dioxide, show a remarkable contrast to one another. Carbon monoxide is poisonous, while we can drink solutions of carbon dioxide gas without danger; in fact, we do so whenever we drink carbonated water or other soda fountain drinks. Carbon monoxide burns with a blue flame, while carbon dioxide does not burn at all and is very efficient in extinguishing fire. Carbon monoxide is practically insoluble, while under pressure carbon dioxide is very soluble indeed. Carbon monoxide is lighter than air, while the dioxide is heavier. Carbon dioxide is an acid substance, whereas carbon monoxide is not. Both gases lack color and odor, so that they are not easily detected, though carbon dioxide will turn lime water a milky color.

The main uses of carbon dioxide are in soda water and other carbonated drinks, in fighting oil fires with foamite, and as dry ice in certain types of modern refrigeration. The chief uses of carbon monoxide are as a fuel gas, both in the home and in factories. Without it, the smelting of many metals would be impossible or very difficult.

In conclusion it is interesting to note that these many and striking differences are due to a very small difference in chemical composition.

NOTE.—Lack of time prevented any discussion on the part of the audience.